Physics 121 Final Examination: Fall 2019 (Day Sections)

A

Name (Print): ________________________________ **4 Digit ID:**________ **Section:** ______

Honors Code Pledge: To promote fair and ethical behavior all students are pledged to comply with the provisions of the NJIT Academic Honor Code. You must answer the exam questions entirely by yourself. **Turn off and put away all cell phones, pagers, or other communication devices**. You may use your own calculator, provided it has no communication capacity.

Instructions:

- First, write your name and section number on both the Scantron form and this exam question book.
- Use the formula sheet at the back of this exam booklet and no other materials.
- The 30 multiple choice questions on this exam are all worth the same amount. There are no extra credit problems. 30 correct answers yield a score of 100%. Allot about 5.0 minutes/question (150 minutes/30 questions).
- Circle your answers on the question papers first to avoid erasures on the Scantron cards. Use a #2 pencil.
- Read and re-read each problem carefully. If you need more space use the backs of exam sheets.
- Do not hesitate to ask for clarification of any exam question, if needed, from your proctor or Professor.

1. Find the product (A X B) X C when A = 7**i** + 7**j**, B = 3**j** - 3**k**, and C = 4**i**

A) 60 **i**
B) 12**k**
C) 84 (j – k)
D) -273
E) 0

2. Two small non-conducting spheres are each given the identical charge. When the two spheres are 2.0 m apart, each sphere is repelled from the other by a force whose magnitude is 6.0 N.
Find the magnitude of the charge on each sphere.

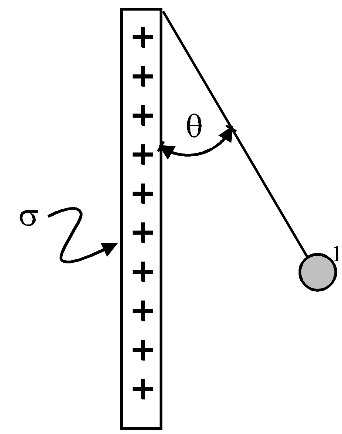
A) 62.1 μC
B) 4.0 μC
C) 7.3 μC
D) 27.4 μC
E) 51.6 μC

3. Which of the following statements describes the magnitude of the electric field outside an infinitely long, hollow cylinder with uniform surface charge density on it? The radial distance referenced is measured from the symmetry axis of the cylinder.

A) It is independent of the radial distance.
B) It is directly proportional to first power of the radial distance.
C) It is directly proportional to the square of the radial distance.
D) It is inversely proportional to the first power of the radial distance.
E) It is inversely proportional to the square of the radial distance.

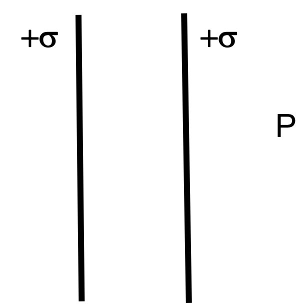
4. A small conducting ball has a mass of 5.0 x 10^{-2} kg and a positive charge of 1 μC. It is attached to a string whose length is 25 cm and it hangs at an angle θ with respect to an infinitely large, insulating sheet as shown in the figure. The sheet has a uniform charge density of σ = 1x10^{-5} C/m^2 on it. The ball is in equilibrium. What is the angle θ?

A) 49 degrees
B) 35 degrees
C) 57 degrees
D) 40 degrees
E) None of the other answers



5. Two infinitely large non-conducting sheets are parallel to each other. Each plate has a uniform, positive surface charge density σ as shown in the sketch - identical in magnitude and sign with **σ = + 6.0 μC/m²**. Find the magnitude and direction of the net electric field at point P – to the right of both sheets.

A) 0
B) 9.0 x 10^5 V/m, pointed right
C) 5.65 x 10^5 V/m, pointed right.
D) 3.4 x 10^5 V/m, pointed left
E) 6.8 x 10^5 V/m, pointed right

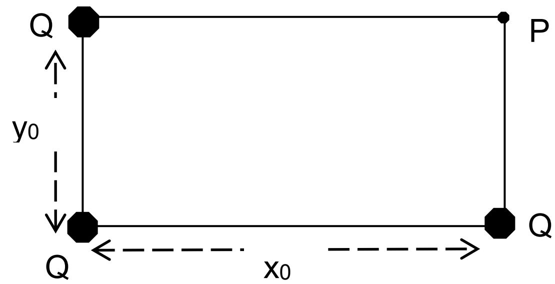


6. An electron is moving through a uniform electric field of 2.0 x 10^{-6} N/C directed East. What are the magnitude and direction of its acceleration, assuming no force other than the electric force is acting? The mass of the electron is approximately 9.1x10^{-31} kg and it's charge is -e. Select the closest answer below.

A) 2 x 10^8 m/s^2 , North
B) 3.5 x 10^5 m/s^2 , West
C) 2 x 10^2 m/s^2 , East
D) 2 x 10^{-2} m/s^2 , West
E) 3.5 x 10^5 m/s^2, East

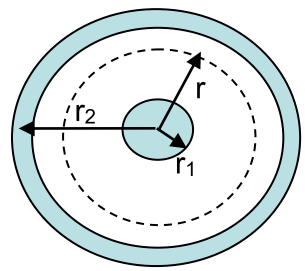
7. Three equal positive charges are located on the corners of a rectangle as shown in the sketch (not drawn to scale). The charges each equal $Q = 10.0\ \mu C$, with $y_0 = 1.5$ m and $x_0 = 2y_0$. Determine the electric potential at point "P" on a corner of the rectangle as shown in the figure.

A) 90,000 V
B) 60,000 V
C) 277,000 V
D) 117,000 V
E) 0 V



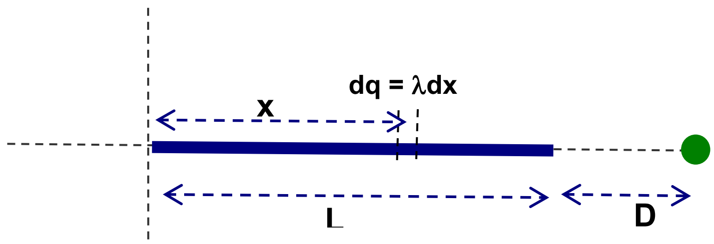
8. A small conducting sphere of radius r_1 carries a charge q_1. A thin metallic spherical shell with a larger radius $r_2 > r_1$) carries a net charge q_2 (see sketch) and is concentric with the first shell. Use Gauss' law to find the electric field formula for a point at radial distance r where $r > r_1$ but $r < r_2$.

A) $E_r = 0$
B) $E_r = k\ q_1 / r^2$
C) $E_r = k\ q_2 / r_2^2$
D) $E_r = k\ (q_1+q_2) / r^2$
E) $E_r = k\ q_1 / r_1^2$



9. Consider a thin rod of total length L = 2.0 m with uniform charge per unit length $\lambda = 4.0\mu C/m$ on it as shown in the figure (not drawn to scale). Find the electric field E due to the continuous charge distribution on the rod at a distance **D = 0.5 m** from the right edge of the rod (as shown in the figure):

A) 5.8×10^4 N/C
B) 1.8×10^5 N/C
C) 3.60×10^5 N/C
D) 1.25×10^5 N/C
E) None of the other answers



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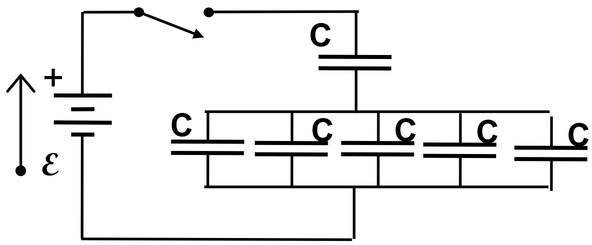
10. The capacitors in the sketch are all identical with capacitances C = 10 nF. Initially they are uncharged. The battery supplies potential difference $\mathcal{E}$ = 3.0 Volts. After the switch is closed, how much charge flows through the battery as all capacitors become fully charged?

A) 12.0 nC
B) 8000 μC
C) 9.0×10^{-3} C
D) 8.3 nC
E) 25.0 nC



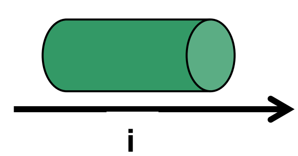
11. A capacitor connected to a 12.0 volt battery is first fully charged up. When it is fully charged, this capacitor is disconnected from the battery and connected in parallel to another identical capacitor which is initially uncharged. The charge on the first capacitor redistributes to both capacitors. What is the final voltage across both capacitors?

A) 3.0 V
B) 6.0 V
C) 4.5 V
D) 9.0 V
E) None of the other answers

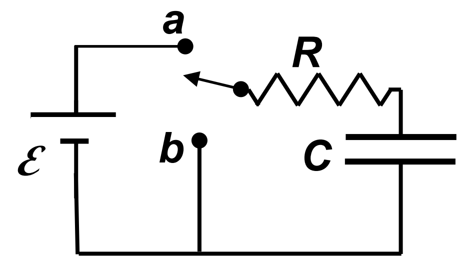
A

12. A current of 6.0 A is flowing through a metal cylinder of radius 3.0 cm. Find the drift velocity for the flowing electrons, assuming that the density of conduction electrons in this metal n = 8.46×10^{22} electrons/m^3.

A) 2.0×10^{22} m/s
B) 0.235 m/s
C) 0.157 m/s
D) 5.87×10^{-2} m/s
E) None of the other choices

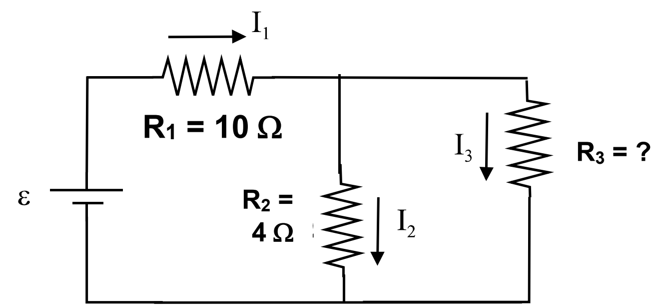


13. The sketch shows an RC series circuit with R = 5.0 MΩ, and C = 100 μF, how long does it take for the capacitor to become charged to 50% of its final value?



A) 1000 s
B) 145 s
C) 865 s
D) 347 s
E) 139 s

14. For the circuit shown in the sketch I_1= 12.0 A and I_3= 7.0 A. What are the magnitude and direction of the current I_2 flowing through R_2?



A) 5.0 A, flowing down
B) 5.0 A, flowing up
C) 3.0 A, flowing down
D) 3.0 A, flowing up
E) Can not determine without knowing the battery EMF and resistor value R_3.

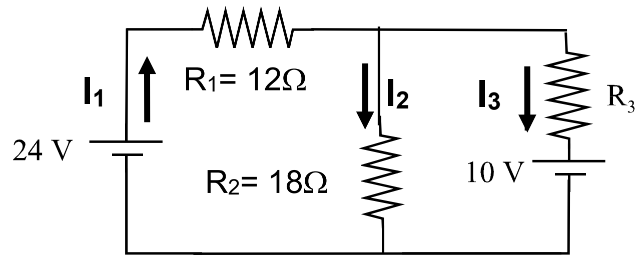
15. For the same circuit shown above, find the magnitude $\mathcal{E}$ of the EMF.

A

A) 38 V
B) 98 V
C) 280 V
D) 140 V
E) 82 V

16. In the multi-loop circuit shown in the figure, the current I_3 in resistor R_3 is 4.0 A and is directed down as indicated in the figure. The magnitude of the current I_1 in the 12 Ω resistor is closest to:

A) Can not be determined without knowing resistance R_3
B) 2.75 A
C) 3.2 A
D) 1.6 A
E) 2.0 A



17. A particle with charge $q = 10^{-9}$ C and mass $m = 2.0 \times 10^{-9}$ kg is moving in a magnetic field whose magnitude is 0.004 T. The speed of the particle is 800 m/s and its velocity vector makes an angle of 45° with the magnetic field vector. What is the magnitude of the acceleration of the particle?

A) 0.53 m/s^2
B) 0.75 m/s^2
C) 1.13 m/s^2
D) 2.1 m/s^2
E) 0.29 m/s^2

A

18. A solenoid with an inductance L = 10 mH is in an RL circuit. At t = 0 the current begins increasing uniformly from zero and reaches 5.0 A after 5 ms. Find the magnitude of the induced EMF.

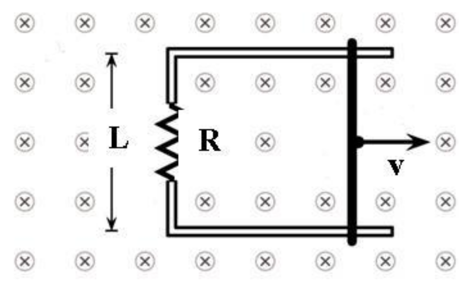
A) 6.4 V
B) 3.2 V
C) 30 V
D) 24 V
E) 10 V

19. A flat circular coil has area A and N turns. It is placed in a magnetic field B that is perpendicular to the plane of the coil. The B field varies periodically with time via the function $B = B_0\cos(\omega t)$, where ω is the angular frequency. Find an expression for the peak magnitude of the EMF $\mathcal{E}_{max}$ induced in the coil?

A) $\mathcal{E}_{max} = 0$
B) $\mathcal{E}_{max} = AB_0\omega$
C)) $\mathcal{E}_{max} = NAB_0$
D) $\mathcal{E}_{max} =$ **$NAB_0\omega$**
E) $\mathcal{E}_{max} = A\omega$

A

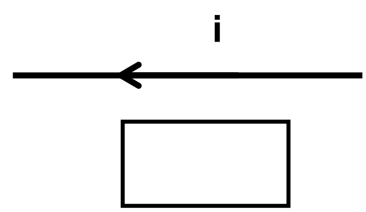
20. The bar in the sketch is moving to the right at constant speed of 40.0 m/s in a uniform magnetic field of 10.0 T directed into the page. The resistance R is 5.0 Ω. The separation L between the rails is 4.0 m. The bar slides with no friction while making continuous electrical contact with the rails. The bar and rails form a circuit enclosing changing magnetic flux and generating EMF $\mathcal{E} = Blv$ while inducing current that flows counter-clockwise in the circuit.



Find the magnitude of the drag force slowing the slider bar down.

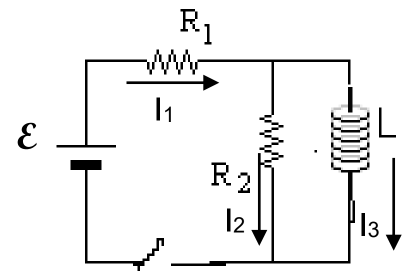
A) 2,000 N
B) 12,800 N
C) 16,000 N
D) 4,000 N
E) Zero

21. In the sketch at right, the current in the long wire is flowing to the left and its magnitude is increasing with time. The induced current in the rectangular loop will be:



A) zero
B) upward on both left and right sides of the loop
C) downward on both left and right sides of the loop
D) counterclockwise
E) clockwise

22. In the figure on the right the resistances are each 20 Ω, L = 5.0 H, and the battery potential $\mathcal{E}$ = 20 V. Find the current through the EMF immediately after the switch is closed at t=0. Hint: how much current is flowing through the inductance at this time?

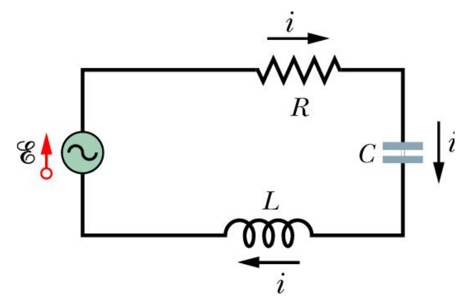


A) 0.50 A
B) 1.0 A
C) 2.0 A
D) 1.5 A
E) 0 A

23. For the circuit used in the previous problem, find the current through resistor R_1 at time t = ∞, after the current through the inductance has reached a constant value.

A) 0.5 A
B) 1.0 A
C) 2.0 A
D) 1.5 A
E) 0 A

The following six questions apply to a series LCR circuit driven by an AC voltage with frequency 240 Hz and R.M.S. voltage of 150 V. The circuit contains a capacitor with C = 2.5 μF, an inductor with L = 0.75 H., and a resistor with R = 200 Ω, all connected in series.



24. Find the impedance of the circuit (select the closest answer).

A) 888 Ω
B) 106 Ω
C) 1131 Ω
D) 265 Ω
E) 630 Ω

A

25. Find the average (RMS) current in the circuit defined above. Select the closest answer.

A) 0.27 A
B) 0.40 A
C) 0.57 A
D) 0.17 A
E) 0.13 A

26. The phase angle for the circuit is closest to:

A) +67°
B) - 62°
C) - 92°
D) +92°
E) +77°

27. The average power dissipated by the circuit is closest to:

A) 3.9 Watts
B) 5.8 Watts
C) 1.8 Watts
D) 7.2 Watts
E) 34 Watts

28. Find the value of the resonant frequency (in Hertz).

A) 25 Hz
B) 730 Hz
C) 116 Hz
D) 36 Hz
E) 69 Hz

29. Find the value of the R.M.S. current that would flow when the circuit is at resonance.

A) 3.20 A.
B) 1.20 A
C) 0.75 A.
D) 1.50 A.
E) 0.50 A.

30. The primary of a step-down transformer has 1000 turns and is connected to a 120 V RMS power connection. The secondary is to supply 12 V RMS at 300 mA. Find the number of secondary turns.

A) 100 turns
B) 40 turns
C) 400 turns
D) 10,000 turns
E) 25 turns

A

Physics 121 (Physics 2) Formulas, page 1 of 2

Area of circle = πr^2 Circumference of circle = $2\pi r$ 1 meter = 1000 mm = 100 cm 1 kg = 1000 g
Surface area of sphere = $4\pi r^2$ Volume of sphere = $(4/3)\pi r^3$, 1 μC = 10^{-6} C 1 nC = 10^{-9} C
$1/4\pi\varepsilon_o = k_e = 9 \times 10^9$ N-m^2/C^2 , $\varepsilon_o = 8.85 \times 10^{-12}$ C^2/N-m^2, $\mu_o = 4\pi \times 10^{-7}$ T-m/A
e = 1.60×10^{-19} C , $m_{electron} = 9.11 \times 10^{-31}$ kg, $m_{proton} = 1.67 \times 10^{-27}$ kg, 1 electron volt (eV) = 1.60×10^{-19} J.

Point charges: $\vec{F} = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}\hat{r}$ $\vec{E} = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2}\hat{r}$ where $\hat{r}$ is a unit vector $k_e \equiv \frac{1}{4\pi\varepsilon_0} = 9\times10^9$

Superposition: contributions to the field or force from point charges add as vectors at a point of interest $\vec{F}_{net\ on\ 1} = \sum_{i=2}^{n}\vec{F}_{1,i} = \vec{F}_{1,2} + \vec{F}_{1,3} + \vec{F}_{1,4+.....}$

Shell Theorem (spheres only): mimics point charge outside; inside **E** or **F** is zero

E = force per unit test charge at a point **F** = q**E** $\mathbf{F}_{net}$ = m**a**

Dipole moment: **p** = q**d** τ_{dipole} = **p**X**E** U_{dipole} = -**p**.**E** $E_{on\ dipole\ axis} \approx +\frac{p}{2\pi\varepsilon_0}\frac{1}{z^3}$ for large z

For continuous charge distributions: $\vec{E} = \int_{dist} k_e \frac{dq}{r^2}\hat{r}$ and $V = \int_{dist} k_e \frac{dq}{r}$ (integrate over the distribution)

σ = surface charge density $E_{conducting\ sheet} = \sigma/\varepsilon_o$ $E_{non\text{-}conducting\ sheet} = \sigma/2\varepsilon_o$
λ = linear charge density $E_{infinite\ line} = \lambda/2\pi\varepsilon_o r$ $E_{finite\ line} = \lambda\sin(\theta_0)/2\pi\varepsilon_o d$ $E_{arc} = \lambda\sin(\theta_0)/2\pi\varepsilon_o R$
$d\Phi_E$ = **E** . **n**dA = EAcos(ϕ) Φ_E = electric flux = q_{enc}/ε_o = $\oint$ **E** . d**A** over a Gaussian surface

$\Delta V = \Delta U/q = -\oint E\cos\theta\, ds = -\oint \mathbf{E}\cdot d\mathbf{s}$ $\Delta U_{el} = q\Delta V$ $V = k_e Q/r$ $U = k_e Qq/r$ $V = -E\,\Delta x$

$E_x = -\partial V/\partial x$ $E_y = -\partial V/\partial y$ $E_z = -\partial V/\partial z$ Q = CV Electrostatic PE: $U_{el} = Q^2/2C = CV^2/2$

$\Delta W_{nc} = \Delta E_{mech} = \Delta K + \Delta U$ $C_{parallel} = \Sigma C_i$ $1/C_{series} = \Sigma(1/C_i)$ $C_{series} = C_1C_2/(C_1+C_2)$
$C_{parallel\ plates} = \kappa\varepsilon_o A/d$ $C_{sphere} = 4\pi\varepsilon_o R$ Dielectric constant: $C_{die;} = \kappa C_{vac}$ $\kappa >= 1$

$q = \oint i\,dt = i\Delta t$ dq = idt i = dq/dt $i = \oint \mathbf{J}\bullet d^2\mathbf{A} = J\Delta A$ $J = qnv_{drift}$ $J = \sigma E$ $\sigma = 1/\rho$

R = V / i V = iR $R = \rho L/A$ $\rho = \rho_0(1 + \alpha(T - T_0))$ Ohms Law: R independent of V

$R_{series} = \Sigma R_i$ $1/R_{parallel} = \Sigma 1/R_i$ $R_{para} = R_1R_2/(R_1 + R_2)$ $P = dU_{el}/dt = iV$ $P_{resistor} = i^2R = V^2/R$

Junction rule: $\Sigma i_{in} = \Sigma i_{out}$ Loop rule: $\Sigma\,\Delta V_i = 0$ around any closed circuit path. $\Delta V = -iR$ when following assumed current, +iR otherwise. Count EMF positive when crossing from – to +, negative otherwise.

RC Circuits: RC = time constant for circuit
charging: $i(t) = (V/R)e^{-t/RC}$ $Q(t) = CV_{cap}(t) = CV_\infty(1 - e^{-t/RC})$
discharging: $i(t) = (Q_o/RC)e^{-t/RC}$ $Q(t) = Q_o e^{-t/RC}$

$\mathbf{F}_m$ = q **v**x**B** $\mathbf{F}_e$ = q**E** $\mathbf{F}_m$ = i **L**x**B** $\boldsymbol{\tau} = \boldsymbol{\mu}\times\mathbf{B}$ U = $-\boldsymbol{\mu}\cdot\mathbf{B}$ $|\mu|$ = NiA normal to loop = magnetic dipole moment. Cyclotron motion : r = mv/(qB) period = $2\pi m/(qB)$ $\omega = qB/m$ $f = \omega/2\pi = 1/$period

Biot Savart: $d\mathbf{B} = \frac{\mu_0}{4\pi}\frac{i\,d\vec{s}\times\hat{r}}{r^2}$ where d**B** is along $d\vec{s}\times\hat{r}$ $\vec{B} = \frac{\mu_0}{4\pi}\frac{q\vec{v}\times\hat{r}}{r^2}$ $\mu_o = 4\pi \times 10^{-7}$ T-m/A

$F/L = \mu_o i_1 i_2/2\pi d$ (2 parallel, straight wires) $B_{arc} = \mu_o i\phi/4\pi R$ $B_{circle} = \mu_o i/2R$ $B_{solenoid} = \mu_0 in$

$B_{infinite\ wire} = \frac{\mu_0 i}{2\pi r}$ $B_{wire} = \frac{\mu_0 i}{4\pi r}[\sin(\theta_1) - \sin(\theta_2)]$ **For symmetric point:** $B_{wire} = \frac{\mu_0 i}{2\pi r}\sin(\theta)$

Amperes law: $\oint \vec{B}\cdot d\vec{s} = \mu_0 i_{enclosed}$ for a closed "Amperian" loop $B_{current\ ring} \approx +\frac{\mu_0}{2\pi_0}\frac{\vec{\mu}}{z^3}$ for large z

Physics 121 (Physics 2) Formulas, page 2 of 2

Magnetic flux: $d\Phi_B = \mathbf{B.dA}$ $\Phi_B = \oint \mathbf{B.dA}$ $\Phi_B = BA\cos(\theta)$ $\Phi_B = 0$ over every *Gaussian* surface

Faraday's Law: $\mathcal{E}_{ind} = -\dfrac{\mathbf{Nd\Phi_B}}{\mathbf{dt}} = \oint_{loop} \mathbf{E_{ind}} \circ \mathbf{d\vec{s}}$

Lenz's Law: induced flux, current, & emf oppose the change in Φ_B

$\mathcal{E}_{ind} = BLv$ (slidewire) $\mathcal{E}_{ind} = NAB\omega \sin(\omega t)$ (rotating coil)

$\mathcal{E}_{\text{self-induced}} = \mathbf{- L\, di/dt}$ $\mathbf{L = N\Phi_B / i}$ Magnetic energy: $\mathbf{U_B = Li^2 / 2}$

LR circuits: L/R= inductive time constant $=\tau_L$

growth phase: $\mathbf{V_L(t) = \mathcal{E}\, e^{-Rt/L}}$ $\mathbf{i(t) = i_{infinity}(1 - e^{-Rt/L})}$ $\mathbf{i_{infinity} = \mathcal{E} / R}$

Decay phase : $\mathbf{V_L(t) = -i_oR\, e^{-Rt/L}}$ $\mathbf{i(t) = i_o\, e^{-Rt/L}}$ $\mathbf{i_0 = \mathcal{E} / R}$

LC circuit, R=0 resonates at $\omega_0 = \mathbf{1 / \sqrt{LC}}$ $Q(t) = Q_0\cos(\omega_0 t+\phi)$ $i(t) = Q_0\, \omega_{0\sigma}\sin(\omega_0 t+\phi)$

LCR circuit with damping: $\mathbf{Q(t) = Q_0 e^{-Rt/2L} \cos(\omega' t + \phi)}$ $\mathbf{Q_0 \equiv C\mathcal{E}}$ $\mathbf{\omega' \equiv \left[\omega_0^2 - (R / 2L)^2\right]^{1/2}}$

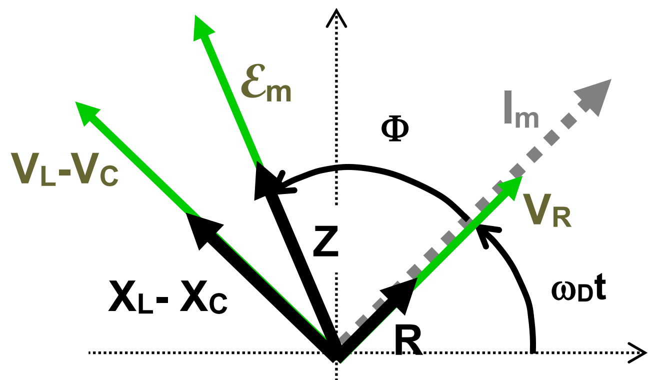
For LCR circuit driven at $\omega_d \mathbf{= 2\pi f}$:

$\mathbf{i(t) = I_{max}\cos(\omega_D t)}$ $\mathbf{\mathcal{E}(t) = \mathcal{E}_{max}\cos(\omega_D t + \Phi)}$

Reactances: $X_C = 1 / \omega_d C$ $X_L = \omega_d L$

Voltage across inductance leads the current by 90°

Voltage across capacitance lags the current by 90°



Impedance, series branch: $\mathbf{|Z| \equiv \sqrt{R^2 + (X_L - X_C)^2}}$

Resonance occurs at $\mathbf{\omega_d = \omega_{res} = 1 / \sqrt{LC}}$

Phase angle Φ: $\mathbf{\tan(\Phi) = (X_L - X_C) / R}$

The power factor = $\cos(\Phi)$. $\mathbf{\cos(\Phi) = R / |Z|}$ $\mathbf{P_{avg} = I_{rms}\mathcal{E}_{rms}\cos(\Phi) = I^2_{rms}R}$

$\mathbf{I_{rms} = I_{max} / \sqrt{2}}$ $\mathbf{\mathcal{E}_{rms} = \mathcal{E}_{max} / \sqrt{2}}$ $\mathbf{I_{rms} = \mathcal{E}_{rms} / |Z|}$ $\mathbf{I_m \equiv \dfrac{\mathcal{E}_m}{|Z|}}$ $\mathbf{I_{rms} \equiv \dfrac{\mathcal{E}_{rms}}{|Z|}}$

Transformers: $\mathbf{V_s / V_p = N_s / N_p = I_p / I_s}$

Prefixes: n (nano) = 10^{-9} , μ (micro) = 10^{-6} , m (milli) = 10^{-3}, M (Mega) = 10^{+6}

Useful Derivatives: $\mathbf{\frac{d}{dt}\sin(\omega t) = \omega\cos(\omega t)}$ $\mathbf{\frac{d}{dt}\cos(\omega t) = -\omega\sin(\omega t)}$ $\mathbf{\frac{d}{dx}e^{\alpha x} = \alpha e^{\alpha x}}$ $\mathbf{\frac{d}{dx}Ax^N = ANx^{N-1}}$

Useful Integrals: $\mathbf{\int x^n dx = x^{n+1} / n+1}$ $\mathbf{\int e^{\pm\alpha x} dx = \pm e^{\alpha x} / \alpha}$

$\int dx / (a^2 + x^2) = (1/a)\tan^{-1}(x/a)$ $\int dx / (a^2 + x^2)^{3/2} = x / (a^2\sqrt{a^2 + x^2})$ $\int x\, dx / (a^2 + x^2)^{3/2} = -1 / \sqrt{a^2 + x^2}$

$\mathbf{\int dx/(a-x)^2 = 1/(a-x)}$ $\mathbf{\int dx / (x^2 + a^2)^{1/2} = \ln(x + (x^2 + a^2)^{1/2})}$ $\mathbf{\int dx/(a+x)^2 = -1/(a+x)}$

$\mathbf{\int xdx / (x^2 + a^2)^{1/2} = (x^2 + a^2)^{1/2}}$ $\mathbf{\int (dx/(a-x) = \ln(|a-x|)}$ $\mathbf{\int (dx/(x+a) = \ln(|x+a|)}$

Physics 1: $v = v_o + at$ $x - x_o = v_o t + ½at^2$ $v^2 = v_o^2 + 2a(x - x_o)$ $x - x_o = ½(v + v_o)t$

$a_{centripetal} = v^2 / r$ $\underline{F}_{net} = m\underline{a} = d\underline{p}/dt$ $\tau_{net} = I\,\alpha = d\underline{L}/dt$ $\underline{\tau} = \underline{r} \times \underline{F}$ $\underline{L} = \underline{r} \times \underline{p}$

Vector Addition: **a + b = c** implies $c_x = a_x + b_x$, $c_y = a_y + b_y$

2D: $a = a_x\mathbf{i} + a_y\mathbf{j}$ $a_x = a\cdot\cos(\theta)$ $a_y = a\cdot\sin(\theta)$ $|a| = \text{sqrt}[a_x^2 + a_y^2]$ $\theta = \tan^{-1}(a_y/a_x)$

3D: $a = a_x\mathbf{i} + a_y\mathbf{j} + a_z\mathbf{k}$ $a_z = a.\cos(\theta)$ $a_x = a.\sin(\theta)\cos(\phi)$ $a_y = a\cdot\sin(\theta)\sin(\phi)$

Dot product: $\mathbf{a\cdot b} = a\cdot b\cdot\cos(\phi) = a_xb_x + a_yb_y + a_zb_z$ unit vectors: $\mathbf{i\cdot i = j\cdot j = k\cdot k} = 1$; $\mathbf{i\cdot j = i\cdot k = j\cdot k} = 0$

Cross product: $|\mathbf{a \times b}| = a\cdot b\cdot\sin(\phi)$; $\mathbf{c = a \times b} = (a_y\cdot b_z - a_z\cdot b_y)\cdot\mathbf{i} + (a_z\cdot b_x - a_x\cdot b_z)\cdot\mathbf{j} + (a_x\cdot b_y - a_y\cdot b_x)\cdot\mathbf{k}$

a x b = – **b x a**, **a x a = 0** always; **c** = **a x b** is perpendicular to **a-b** plane; if **a** || **b** then | **a x b** | = 0

i x i = **j x j** = **k x k** = 0, **i x j = k** **j x k = i** **k x i = j**

KEY - Physics 121 Fall 2019 Final Exam (Day) Ver. A & B

1.	C	84 (j – k)
2.	E	51.6 μC
3.	D	It is inversely proportional to the first power of the radial distance.
4.	A	49 degrees
5.	E	6.8×10^5 V/m pointing right
6.	B	3.5×10^5 m/s^2, West
7.	D	117,000 V
8.	B	$E_r = k\, q_1 / r^2$
9.	A	5.8×10^4 N/C
10.	E	25 nC
11.	B	6.0 V
12.	C	0.157 m/s
13.	D	347 s
14.	A	5.0 A flowing down
15.	D	140 V
16.	C	3.2 A
17.	C	1.13 m/s^2
18.	E	10 V
19.	D	$\mathcal{E}_{max} = NAB_0\omega$
20.	B	12800 N
21.	E	clockwise
22.	A	0.50 A
23.	B	1.0 A
24.	A	888 Ω
25.	D	0.17 A
26.	E	+77°
27.	B	5.8 Watts
28.	C	116 Hz
29.	C	0.75 A
30.	A	100 turns

A&B